



Published in final edited form as:

J Asthma. 2015 February ; 52(1): 46–51. doi:10.3109/02770903.2014.944984.

Employed adults with asthma who have frequent workplace exposures

Gretchen E. White, MPH, Jacek M. Mazurek, MD, MS, PhD, and Eileen Storey, MD, MPH

Division of Respiratory Disease Studies, National Institute for Occupational Safety and Health, Centers for Disease Control and Prevention, Morgantown, WV, USA

Abstract

Objective—The recent increase in asthma prevalence is thought to be partially due to environmental changes such as changes in air pollution and occupational exposures. Nationally representative information on workplace exposures among US adults with asthma is limited.

Methods—We examined 2010 National Health Interview Survey data to determine the proportion of employed adults with asthma who had frequent workplace exposures.

Results—Among adults with current asthma, 19.6% frequently worked outdoors, 17.5% were frequently exposed to workplace secondhand smoke and 28.1% were frequently exposed to workplace vapors, gas, dust or fumes. Adults ever told by a health professional that asthma is probably work-related, when compared to adults who were not, had increased odds of frequent work outdoors [prevalence odds ratio (POR) = 2.76], frequent workplace exposure to secondhand smoke (POR = 3.08) and frequent workplace exposure to vapors, gas, dust or fumes (POR = 3.56).

Conclusions—To our knowledge, this is the first population-based study in USA that estimates the proportion of working adults with asthma that have frequent workplace exposures. Increasing the understanding of workplace exposures among adults with asthma will help enable prevention of asthma through workplace exposure reduction or avoidance. Future studies should further examine industries and occupations of individuals with asthma and frequent workplace exposures.

Keywords

Asthma; dust; fumes; gas; NHIS; occupational exposure; secondhand smoke

Introduction

The prevalence of asthma in adults has significantly increased in USA from 6.9% in 2001 to 8.0% in 2012 [1]. In 2010, nearly 19 million adults in USA had current asthma [2]. The increase in asthma prevalence is thought to be partially due to environmental changes such

Correspondence: Dr. Jacek M. Mazurek, Division of Respiratory Disease Studies, National Institute for Occupational Safety and Health, Centers for Disease Control and Prevention, 1095 Willowdale Rd, MS HG-900.2, Morgantown, WV 26505, USA. Tel: +1(304) 285-5983. Fax: +1(304) 285-6111. JMazurek1@cdc.gov.

Declaration of interest

The authors received no funding for this work and have no conflicts of interest to disclose.

The findings and conclusions in this report are those of the authors and do not necessarily represent the views of the National Institute for Occupational Safety and Health.

as changes in air pollution and occupational exposures [3,4]. Adult asthma is associated with a large number of agents, including over 350 that can be found in the workplace [5]. An estimated 17% of adult-onset asthma is attributable to workplace exposures [6] and an estimated 22% of asthma in working adults is exacerbated by workplace exposures [7]. Asthma caused or made worse by workplace exposures (work-related asthma) is preventable and control of this condition relies on control of the offending workplace exposure through avoidance or reduction [8].

Identifying workplace respiratory exposures may be useful in revising current strategies or developing new prevention programs for asthma and work-related asthma. For example, exposures to occupational hazards can be prevented through substitution, by conducting workplace engineering evaluations and developing control technology interventions, and by evaluating work practices [9]. When respiratory exposures cannot be avoided, respirators may be used. Several factors must be considered when selecting respirators, including physical, chemical and toxicological properties of the contaminant and its expected concentration [10]. Use of respirators among individuals already affected by work-related asthma may result in improvement, but not complete suppression, of asthma symptoms [11].

During 1981–1983, the National Institute for Occupational Safety and Health (NIOSH) conducted the National Occupational Exposure Survey (NOES) to collect data on potential occupational exposures to chemical, physical and biological agents (<http://www.cdc.gov/noes/>). Because of the ongoing changes to workplace production processes, job tasks, work schedules and changes to the workforce, more current data on workplace exposures were needed. In 2013, using 2010 National Health Interview Survey (NHIS) Occupational Health Supplement data, Calvert et al. [12] reported that an estimated 24.7% of adults employed in the past year frequently worked outdoors; 25.0% were frequently exposed to vapors, gas, dust or fumes; and 10.0% of non-smokers were frequently exposed to secondhand smoke at work; and that these potentially hazardous workplace exposures varied by industry and occupation.

Workers with asthma and work-related asthma are at risk for asthma exacerbation with exposure at work [7]. No nationally representative information on the proportion of working adults with asthma that experience frequent workplace exposures potentially relevant to asthma is available in USA. To address this gap, we determined the proportion of adults employed in the past year with current asthma that had frequent workplace exposures using the 2010 NHIS Occupational Health Supplement data.

Methods

Data source

The NHIS is a cross-sectional household interview survey with continuous sampling and interviewing throughout the year in which one randomly selected adult (aged >18 years) household member is interviewed in person. The National Center for Health Statistics conducts the survey annually in collaboration with the US Census Bureau to collect health information on the civilian non-institutionalized US population. In 2010, NIOSH sponsored an Occupational Health Supplement to the 2010 NHIS in order to collect information on

occupational health conditions including asthma in relation to work. The 2010 NHIS sample adult response rate was 60.8% [13]. The 2010 NHIS received Institutional Review Board approval from the National Center for Health Statistics (Research Ethics Review Board protocol no. 2009-16). All 2010 NHIS respondents provided oral consent prior to participation in the survey. The 2010 NHIS questionnaire, dataset and related documentation are available at: http://www.cdc.gov/nchs/nhis/quest_data_related_1997_forward.htm and information on the 2010 NHIS Occupational Health Supplement is available from: http://www.cdc.gov/nchs/nhis/supplements_cosponsors.htm.

Definitions

We defined respondents employed in the past year as those who (i) were “working for pay at a job or business”, “with a job or business but not at work” or “working, but not for pay, at a family owned job or business” during the week prior to the NHIS interview and (ii) among respondents who were “looking for work” or “not working at a job or business and not looking for work” during the week prior to the interview, those who answered “yes” to the questions: “have you ever held a job or worked at a business?” and “although you did not work last week, did you have a job or business at any time in the past 12 months?”.

We defined respondents as having current asthma if they answered “yes” to the questions, “have you ever been told by a doctor or other health professional that you had asthma?” and “do you still have asthma?”. We defined asthma that was probably work-related as a “yes” response to the question “have you ever been told by a doctor or other health professional that your asthma could be or probably was work-related?”. Adults employed in the past year with current asthma were also asked a series of questions on asthma outcomes in the 12 months prior to the interview such as having an asthma attack or episode and having an emergency room visit or urgent care visit for their asthma.

A series of questions on potential workplace exposures were asked of respondents who were employed in the past year. Frequent work outdoors was defined by a “yes” response to the question “during the past 12 months, did you regularly work outdoors twice a week or more?” Frequent workplace exposure to secondhand smoke was defined by a “yes” response to the question “during the past 12 months, were you regularly exposed to tobacco smoke from other people at work twice a week or more?”. We defined frequent workplace exposure to vapors, gas, dust or fumes as a “yes” response to the question “please tell me if you are/were regularly exposed to vapors, gas, dust or fumes at work twice a week or more?”. The questions on frequent work outdoors and frequent exposure to secondhand smoke at work were pertinent to the main job the respondent held in the week prior to the interview. If the respondent was not working in the week prior to the interview, the questions addressed the job held most recently. The question on frequent workplace exposure to vapors, gas, dust or fumes was pertinent to the respondent’s longest held job. Research has shown that a single question on vapors, gas, dust or fume exposures defines exposure risk as well as multiple-item questions [14].

Data analysis

We analyzed data using SAS[®] software (version 9.3; SAS Institute Inc., Cary, NC) survey procedures. Data were weighted to account for the probability of selection and to adjust for participant non-response [13]. All estimates in this report have relative standard errors <30% and represent the US population aged 18 years employed in the past year with current asthma.

We examined the proportions of adults employed in the past year with current asthma that had frequent workplace exposures. We also examined frequent workplace exposures among adults employed in the past year with current asthma by select characteristics. We compared proportions using χ^2 statistics. Using multivariable logistic regression to calculate adjusted prevalence odds ratios (PORs), we examined associations between select characteristics and frequent work-place exposures. For each workplace exposure, we adjusted for all variables that were significantly associated with that particular workplace exposure as determined by the χ^2 statistics. All test results were determined statistically significant at p value <0.05.

Results

A total of 1227 NHIS Occupational Health Supplement respondents (representing an estimated 11.1 million adults) were employed in the past year and had current asthma. Characteristics of adults employed in the past year with current asthma have previously been published [15]. Among adults employed in the past year with current asthma, an estimated 19.6% frequently worked outdoors, 17.5% were frequently exposed to secondhand smoke in the workplace and 28.1% were frequently exposed to vapors, gas, dust or fumes in the workplace. Among adults employed in the past year with current asthma, an estimated 6.6% had ever been told by a health professional that their asthma was probably work-related [16]. When compared to adults who were never told by a health professional that their asthma was probably work-related, adults who were told that their asthma was probably work-related had higher proportions who frequently worked outdoors (34.1 versus 18.5%; $p = 0.003$) and were frequently exposed to secondhand smoke at work (31.8 versus 16.5%; $p = 0.001$) in their current or most recent job; and were frequently exposed to vapors, gas, dust or fumes at work (51.2 versus 26.5%; $p < 0.0001$) at their longest held job (Table 1).

In bivariate analyses, sex, education, income, health insurance, smoking status and being told that asthma is probably work-related were independently associated with frequently working outdoors and were included in multivariable logistic regression. After adjusting for covariates, the following groups had significantly elevated odds of frequently working outdoors: males compared to females (POR = 4.29), those with high school education compared to those with more than a high school education (POR = 1.70), those with an annual income of \$35 000–\$74 999 compared to those with an annual household income \$75 000 (POR = 1.95), those without health insurance compared to those with health insurance (POR = 1.66), those with an asthma attack in the past year compared to those without an asthma attack in the past year (POR = 1.41) and those who were told that their asthma is probably work-related compared to those who were not (POR = 2.76) (Table 1).

In bivariate analyses, age, sex, education, income, health insurance, smoking status, emergency room or urgent care visit for asthma and being told that asthma is probably work-related were independently associated with frequent exposure to secondhand smoke at work and were included in multivariable logistic regression. After adjusting for covariates, the following groups had significantly elevated odds of frequent secondhand smoke exposure in the work-place: those 18–29 years old compared to those ≥45 years (POR = 2.04), males compared to females (POR = 2.19), those without health insurance compared to those with health insurance (POR = 2.96), current smokers compared to never smokers (POR = 2.92) and those who were told that their asthma is probably work-related compared to those who were not (POR = 3.08) (Table 1).

In bivariate analyses, age, sex, education, income, health insurance, smoking status and being told that asthma is probably work-related were independently associated with frequent workplace exposure to vapors, gas, dust or fumes and were included in multivariable logistic regression. After adjusting for covariates, the following groups had significantly elevated odds of frequent workplace exposure to vapors, gas, dust or fumes: males compared to females (POR = 2.48), persons with a high school education compared to those with more than high school education (POR = 2.07), those with an annual income of \$35 000–\$74 999 compared to those with an annual household income ≤\$75 000 (POR = 1.63), those with an asthma attack in the past year compared to those without an asthma attack in the past year (POR = 1.55) and those who were told that their asthma is probably work-related compared to those who were not (POR = 3.56) (Table 1).

Discussion

These results show that between 17.5 and 28.1% of adults with current asthma and between 31.8 and 51.2% of adults who were told that their asthma is probably work-related asthma are frequently exposed to workplace exposures which may play a role in asthma onset or exacerbation. We found that an estimated 19.6% of adults employed in the past year with current asthma frequently worked outdoors which is lower than the estimate by Calvert et al. [12] in all adults employed in the past year (24.7%). This may suggest the healthy worker effect where persons with asthma are less likely to be hired into or remain in jobs with significant exposures [12,17]. In addition, individuals with childhood asthma may avoid occupations that may be associated with increased risk of asthma symptom exacerbation [18–23]. In contrast, we found slightly higher estimated proportions of adults employed in the past year with asthma who were frequently exposed to vapors, gas, dust or fumes at work in their longest held job than Calvert et al. [12] found in all adults employed in the past year (28.1 versus 25.0%, respectively).

A variety of respiratory triggers are associated with work outdoors. These agents may include pollen [24], grass cuttings [25], hot and cold weather [24], and pesticides [26] which are all associated with multiple cases of work-related asthma in sentinel surveillance data [26]. Additionally, outdoor air pollutants are associated with pulmonary inflammation, decreased lung function and asthma exacerbation [27].

Calvert et al. [12] found that, among non-smokers employed in the past year, 10% were frequently exposed to secondhand smoke in the workplace and that this prevalence was higher in the mining and construction industries. This is lower than what we found among current non-smokers with asthma in this study (12.2% of never smokers and 18.6% of former smokers) indicating that workers with asthma have more frequent exposure to workplace secondhand smoke [12]. We found in our bivariate analysis that frequent workplace exposure to secondhand smoke was higher among adults 18–29 years old. This may partially be explained by young adults working in industries and occupations where they are frequently exposed to secondhand smoke. For example, in the accommodation and food services industry, where workers are less likely than other workers to be protected by smoke-free workplace policies, the median age of workers is 30 years old compared to the median age of all workers which is 42.3 years [28,29]. In children with asthma, secondhand smoke exposure is associated with increased rates of healthcare utilization and asthma exacerbations [30,31]. Results from a case-control study of incident asthma in adults indicate that adults with workplace exposure to environmental tobacco smoke have higher odds of developing asthma than those not exposed to environmental tobacco smoke at work [32]. Exposure to secondhand smoke in the workplace can have far-reaching consequences. In 2008, Stanbury et al. [33] reported that a waitress died from asthma associated with work-related environmental tobacco smoke at the bar where she worked.

In USA, progress has been made in the adoption of comprehensive smoke-free laws in most states and in the 50 largest US cities [34,35]. However, in 2010, 48% of states and in 2012, 40% of the 50 largest US cities still did not have comprehensive smoke-free laws protecting workers in all indoor areas of private workplaces, restaurants and bars [34,35]. A study examining the impact of smoke-free legislation in UK found a 4.9% reduction in emergency room admissions for asthma among adults after the initiation of smoke-free legislation [36].

We found that males had significantly higher odds of all measures of frequent workplace exposures of concern when compared to females. This may be because of differences in the occupations and industries in which males and females work as well as differences in job task by gender [37,38]. Interestingly, frequent exposure to vapors, dust, gas or fumes at work and frequent work outdoors differed by education and income while frequent exposure to secondhand smoke at work did not.

The strength of this study is that it provides recent population-based information on workplace exposures among adults with asthma in USA. However, because of the cross-sectional design of the survey, we were unable to assess the temporal relationship between asthma onset and workplace exposures. We were also unable to determine whether the workplace exposure categories examined occurred in the same job the respondent had when their asthma symptoms first developed. This may explain, in part, why more adults with work-related asthma did not report the specific workplace exposures examined here. Moreover, due to small sample sizes, we were unable to further examine the characteristics of individuals with work-related asthma and workplace exposures. We were also unable to examine workplace secondhand smoke exposure among non-smokers or workplace exposures among adults with asthma in specific industry and occupation groups due to small sample sizes. Research by Calvert et al. [12] found that the proportion of workers exposed to

workplace exposures such as frequent work outdoors, frequent exposure to secondhand smoke in the workplace and frequent exposure to vapors, gas, dust and fumes at work varied by both industry and occupation. Additionally, because adults not employed in the past year were not included in this analysis, our estimates of the proportion of adults with asthma frequently exposed to vapors, gas, dust or fumes in their longest held job may be underestimated, particularly if individuals with asthma and workplace exposure to vapors, gas, dust or fumes withdrew from the workforce.

Conclusion

To our knowledge, this is the first population-based study in USA that examines the proportion of working adults with asthma that have frequent workplace exposures pertinent to asthma onset or exacerbation. As expected, we found that individuals who were told that their asthma is probably work-related had higher proportions of frequent workplace exposure than individuals who were not. This may reflect increased frequent workplace exposure in adults with work-related asthma but may also indicate that physicians are more likely to recognize and diagnose work-related asthma in individuals with frequent workplace exposures. Increasing the understanding of workplace exposures among adults with asthma will help enable the prevention of asthma through workplace exposure reduction or avoidance [7,8]. Future studies should further examine industries and occupations of individuals with frequent workplace exposures.

Acknowledgements

We thank Maria C. Mirabelli, PhD, MPH, National Center for Environmental Health, Centers for Disease Control and Prevention (CDC) and Laura Kurth, PhD, National Institute for Occupational Safety and Health (NIOSH), CDC, for their helpful comments. We thank Sara E. Luckhaupt, MD, NIOSH, CDC, for her active role as the Project Officer for the National Health Interview Survey Occupational Health Supplement. The Supplement was successfully completed because of her leadership. We thank James M. Dahlhamer, PhD and Brian W. Ward, PhD, National Center for Health Statistics, CDC, for their contribution to the National Health Interview Survey Occupational Health Supplement survey planning, questionnaire development, and data collection and preparation for public use.

References

- Centers for Disease Control and Prevention. Asthma National Health Interview Survey (NHIS) data. Atlanta, GA: 2014. Available from: <http://www.cdc.gov/Asthma/nhis/default.htm> [last accessed 16 Jun 2014]
- Moorman J, Akinbami L, Bailey C, Zahran HS, King ME, Johnson CA, Liu X. National surveillance of asthma: United States, 2001–2010. *Vital Health Stat.* 2012; 3:1–67.
- von Mutius E. Gene-environment interactions in asthma. *J Allergy Clin Immunol.* 2009; 123:3–11. [PubMed: 19130922]
- Becklake MR, Ernst P. Environmental factors. *Lancet.* 1997; 350:SII10–SII13. [PubMed: 9343098]
- Malo JL, Chan-Yeung M. Agents causing occupational asthma. *J Allergy Clin Immunol.* 2009; 123:545–550. [PubMed: 18951622]
- Toren K, Blanc PD. Asthma caused by occupational exposures is common - a systematic analysis of estimates of the population-attributable fraction. *BMC Pulm Med.* 2009; 9:7. [PubMed: 19178702]
- Henneberger PK, Redlich CA, Callahan DB, Harber P, Lemiere C, Martin J, Tarlo SM, et al. An official american thoracic society statement: work-exacerbated asthma. *Am J Respir Crit Care Med.* 2011; 184:368–378. [PubMed: 21804122]

8. Tarlo SM, Balmes J, Balkissoon R, Beach J, Beckett W, Bernstein DI, Blanc PD, et al. Diagnosis and management of work-related asthma: American College Of Chest Physicians Consensus Statement. *Chest*. 2008; 134:1S–41S. [PubMed: 18779187]
9. Centers for Disease Control and Prevention. Working safety and health topics: engineering controls. Atlanta, GA: 2011. Available from: <http://www.cdc.gov/niosh/topics/engcontrols/> [last accessed 16 Dec 2013]
10. Bollinger, N. NIOSH Respirator Selection Logic [2005-100]. US Department of Health and Human Services, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health; Atlanta, GA: 2004. Available from: <http://www.cdc.gov/niosh/docs/2005-100/> [last accessed 10 Feb 2014]
11. Baur X, Sigsgaard T, Aasen TB, Burge PS, Heederik D, Henneberger P, Maestrelli P, et al. Guidelines for the management of work-related asthma. *Eur Respir J*. 2012; 39:529–545. [PubMed: 22379148]
12. Calvert G, Luckhaupt S, Sussell A, Dahlhamer J, Ward B. The prevalence of selected potentially hazardous workplace exposures in the US: findings from the 2010 National Health Interview Survey. *Am J Ind Med*. 2013; 56:635–646. [PubMed: 22821700]
13. Centers for Disease Control and Prevention. 2010 National Health Interview Survey (NHIS) public use data release, NHIS survey description. Hyattsville, MD: 2011. Available from: ftp://ftp.cdc.gov/pub/Health_Statistics/NCHS/Dataset_Documentation/NHIS/2010/srvydesc.pdf [last accessed 16 Jul 2012]
14. Blanc P, Eisner MD, Balmes JR, Trupin L, Yelin EH, Katz PP. Exposure to vapors, gas, dust, or fumes: assessment by a single survey item compared to a detailed exposure battery and a job exposure matrix. *Am J Ind Med*. 2005; 48:110–117. [PubMed: 16032739]
15. Knoeller GE, Mazurek JM, Storey E. Occupation held at the time of asthma symptom development. *A J Ind Med*. 2013; 56:1165–1173.
16. Mazurek JM, Storey E. Physician-patient communication regarding asthma and work. *Am J Prev Med*. 2012; 43:72–75. [PubMed: 22704750]
17. Le Moual N, Kauffmann F, Eisen EA, Kennedy SM. The healthy worker effect in asthma: work may cause asthma, but asthma may also influence work. *Am J Respir Crit Care Med*. 2008; 177:4–10. [PubMed: 17872490]
18. Mazurek J, Schleiff P, Henneberger P. Is childhood asthma associated with educational level and longest-held occupation? *Am J Epidemiol*. 2012; 175:279–288. [PubMed: 22223711]
19. Kraut A, Walld R, Mustard C. Prevalence of physician-diagnosed asthma by occupational groupings in Manitoba, Canada. *Am J Ind Med*. 1997; 32:275–282. [PubMed: 9219658]
20. Wiebert P, Svartengren M, Lindberg M, Hemmingsson T, Lundberg I, Nise G. Mortality, morbidity and occupational exposure to airway-irritating agents among men with a respiratory diagnosis in adolescence. *Occup Environ Med*. 2008; 65:120–125. [PubMed: 17681997]
21. Bhinder S, Cicutto L, Abdel Qadir H, Tarlo S. Perception of asthma as a factor in career choice among young adults with asthma. *Can Respir J*. 2009; 16:e69–e75. [PubMed: 20011720]
22. Olivieri M, Mirabelli MC, Plana E, Radon K, Anto JM, Bakke P, Benke G, et al. Healthy hire effect, job selection and inhalation exposure among young adults with asthma. *Eur Respir J*. 2010; 36:517–523. [PubMed: 20185427]
23. Dumas O, Smit LAM, Pin I, Kromhout H, Siroux V, Nadif R, Vermeulen R, et al. Do young adults with childhood asthma avoid occupational exposures at first hire? *Eur Respir J*. 2011; 37:1043–1049. [PubMed: 20884739]
24. Canova C, Heinrich J, Anto JM, Leynaert B, Smith M, Kuenzli N, Zock JP, et al. The influence of sensitisation to pollens and moulds on seasonal variations in asthma attacks. *Euro Resp J*. 2013; 42:935–945.
25. Kotaniemi JT, Pallasaho P, Sovijarvi ARA, Laitinen L, Lundback B. Respiratory symptoms and asthma in relation to cold climate, inhaled allergens, and irritants: a comparison between Northern and Southern Finland. *J Asthma*. 2002; 39:649–658. [PubMed: 12442955]
26. The National Institute for Occupational Safety and Health (NIOSH). Work-Related Lung Disease surveillance system (eWoRLD) [2012T09-05A]. US Department of Health and Human Services, Public Health Service, Centers for Disease Control and Prevention, National Institute for

- Occupational Safety and Health, Division of Respiratory Disease Studies, Surveillance Branch; Morgantown, WV: 2012. Available from: <http://www2a.cdc.gov/drds/WorldReportData/> [last accessed 4 Nov 2013]
27. Laumbach R. Outdoor air pollutants and patient health. *Am Fam Physician*. 2010; 81:175–180. [PubMed: 20082513]
 28. US Bureau of Labor Statistics. Labor force statistics from the current population survey: employed persons by detailed industry and age, 2012 annual averages. US Department of Labor; Washington, DCL: 2012. Current Population Survey. Available from: http://www.bls.gov/cps/industry_age.htm [last accessed 10 Febr 2014]
 29. Centers for Disease Control and Prevention. The health consequences of involuntary exposures to tobacco smoke: a report of the surgeon general. Department of Health and Human Services, US Department of Health and Human Services; Atlanta, GA: 2006. p. 571-665. Available from: <http://www.surgeongeneral.gov/library/reports/secondhandsmoke/fullreport.pdf> [last accessed 10 Feb 2014]
 30. Jin Y, Seiber E, Ferketich A. Secondhand smoke and asthma: what are the effects on healthcare utilization among children? *Prev Med*. 2013; 57:125–128. [PubMed: 23701846]
 31. McCarville M, Sohn M-W, Oh E, Weiss K, Gupta R. Environmental tobacco smoke and asthma exacerbations and severity: The difference between measured and reported exposure. *Arch Dis Child*. 2013; 98:510–514. [PubMed: 23606711]
 32. Jaakkola MS, Piipari R, Jaakkola N, Jaakkola JJ. Environmental tobacco smoke and adult-onset asthma: a population-based incident case-control study. *Am J Public Health*. 2003; 93:2055–2060. [PubMed: 14652334]
 33. Stanbury M, Chester D, Hanna E, Rosenman K. How many deaths will it take? A death from asthma associated with work-related environmental tobacco smoke. *Am J Ind Med*. 2008; 51:111–116. [PubMed: 18067177]
 34. Centers for Disease Control and Prevention. State smoke-free laws for worksites, restaurants, and bars – United States, 2000–2010. *MMWR*. 2011; 60:472–475. [PubMed: 21508923]
 35. Centers for Disease Control and Prevention. Comprehensive smoke-free laws - 50 largest US cities, 2000 and 2012. *MMWR*. 2012; 61:914–917. Reported by: M Hopkins, C Hallett, S Babb, B King, M Tynan, A MacNeil. [PubMed: 23151950]
 36. Sims M, Maxwell R, Gilmore A. Short-term impact of the smokefree legislation in England on emergency hospital admissions for asthma among adults: a population-based study. *Thorax*. 2013; 68:619–624. [PubMed: 23589509]
 37. Camp P, Dimich-Ward H, Kennedy SM. Women and occupational lung disease: sex differences and gender influences on research and disease outcomes. *Clin Chest Med*. 2004; 25:269–279. [PubMed: 15099888]
 38. US Bureau of Labor Statistics. Women in the labor force: a databook. February: 2013. Report 1040. BLS Reports

Table 1

Proportion of adults with current asthma employed in the past year who had frequent workplace exposures.

Characteristic (number in sample ^a)	Frequent work outdoors		Frequent exposure to secondhand smoke at work		Frequent exposure to vapors, gas, dust or fumes at work	
	% ^b (95% CI)	POR ^c (95% CI)	% ^a (95% CI)	POR ^d (95% CI)	% ^a (95% CI)	POR ^e (95% CI)
Age group in years						
18–29 (316)	20.7 (15.2–26.2)	1.07 (0.68–1.68)	23.6 (17.7–29.4) ^f	2.04 (1.23–3.40)	25.2 (19.2–31.2)	0.81 (0.54–1.21)
30–44 (411)	20.8 (16.2–25.5)	1.11 (0.75–1.66)	18.2 (14.0–22.4)	1.43 (0.91–2.25)	28.5 (23.6–33.5)	0.90 (0.63–1.28)
45+ (500)	17.7 (13.5–21.9)	1.00 (ref)	12.6 (8.7–16.4)	1.00 (ref)	30.0 (25.4–34.5)	1.00 (ref)
Sex						
Male (399)	34.7 (29.0–40.4) ^f	4.29 (3.09–5.96)	24.8 (19.5–30.1) ^f	2.19 (1.48–3.26)	40.5 (34.8–46.1) ^f	2.48 (1.84–3.35)
Female (828)	10.9 (8.5–13.4)	1.00 (ref)	13.4 (10.6–16.2)	1.00 (ref)	21.1 (17.7–24.5)	1.00 (ref)
Race						
White (875)	19.5 (16.5–22.5)	1.00 (ref)	16.5 (13.4–19.6)	1.00 (ref)	28.9 (25.2–32.5)	1.00 (ref)
Non-White ^g (351)	19.8 (14.0–25.7)	0.88 (0.57–1.34)	21.5 (16.1–26.9)	1.33 (0.86–2.05)	25.4 (20.0–30.7)	0.76 (0.55–1.06)
Hispanic ethnicity						
Hispanic (185)	27.5 (18.1–36.9)	1.43 (0.89–2.29)	17.9 (10.9–24.9)	0.79 (0.48–1.31)	35.8 (26.9–44.7)	1.32 (0.88–1.97)
Non-Hispanic (1042)	18.5 (15.7–21.4)	1.00 (ref)	17.5 (14.5–20.5)	1.00 (ref)	27.1 (23.8–30.4)	1.00 (ref)
Education						
Less than high school (93)	22.5 (12.8–32.3) ^f	1.31 (0.70–2.45)	35.6 (22.7–48.6) ^f	1.90 (0.82–4.39)	34.3 (22.9–45.7) ^f	1.63 (0.93–2.85)
High school graduate (264)	29.1 (21.9–36.2)	1.70 (1.12–2.58)	22.5 (16.0–29.0)	1.19 (0.76–1.85)	40.0 (32.1–47.9)	2.07 (1.41–3.03)
More than high school (868)	16.5 (13.4–19.6)	1.00 (ref)	14.6 (11.4–17.7)	1.00 (ref)	24.0 (20.5–27.5)	1.00 (ref)
Income						
\$34 999 (419)	22.3 (17.1–27.6)	1.48 (0.92–2.38)	24.5 (19.1–29.9)	1.02 (0.62–1.69)	28.5 (23.2–33.8)	1.09 (0.71–1.66)
\$35 000–\$74 999 (401)	24.4 (19.3–29.6)	1.95 (1.27–2.99)	19.7 (14.9–24.5)	1.37 (0.83–2.25)	33.9 (28.2–39.6)	1.63 (1.10–2.41)
\$75 000 (363)	13.6 (9.8–17.4) ^f	1.00 (ref)	11.6 (7.5–15.6) ^f	1.00 (ref)	22.9 (17.6–28.1) ^f	1.00 (ref)
Health insurance						
Not covered (194)	30.8 (22.2–39.5) ^f	1.66 (1.03–2.69)	39.3 (30.1–48.5) ^f	2.96 (1.73–5.06)	35.9 (27.6–44.2) ^f	1.20 (0.79–1.82)
Covered (1028)	17.7 (15.0–20.4)	1.00 (ref)	13.9 (11.3–16.6)	1.00 (ref)	27.0 (23.6–30.4)	1.00 (ref)
Smoking status						
Never (736)	18.4 (14.9–22.0)	1.00 (ref)	12.2 (8.9–15.5) ^f	1.00 (ref)	25.2 (21.4–29.0) ^f	1.00 (ref)
Former (251)	20.8 (14.7–26.8)	0.99 (0.63–1.54)	18.6 (12.3–25.0)	1.64 (0.97–2.76)	33.8 (26.9–40.6)	1.32 (0.91–1.91)
Current (235)	22.4 (16.0–28.9)	0.94 (0.60–1.48)	34.5 (27.5–41.5)	2.92 (1.83–4.66)	32.0 (24.2–39.8)	1.05 (0.69–1.59)
Asthma attack ^h						
No (602)	19.0 (14.9–23.0)	1.00 (ref)	16.1 (12.3–19.8)	1.00 (ref)	25.3 (21.0–29.5)	1.00 (ref)
Yes (325)	20.2 (16.6–23.7)	1.41 (1.00–1.99)	19.1 (15.2–22.9)	1.27 (0.81–1.99)	31.0 (26.5–35.4)	1.55 (1.14–2.11)
Emergency room/urgent care visit ^h						
No (1086)	19.2 (16.4–22.0)	1.00 (ref)	16.7 (13.8–19.5) ^f	1.00 (ref)	27.9 (24.6–31.1)	1.00 (ref)

Characteristic (number in sample ^a)	Frequent work outdoors		Frequent exposure to secondhand smoke at work		Frequent exposure to vapors, gas, dust or fumes at work	
	% ^b (95% CI)	POR ^c (95% CI)	% ^a (95% CI)	POR ^d (95% CI)	% ^a (95% CI)	POR ^e (95% CI)
Yes (141)	22.9 (14.4–31.5)	1.47 (0.87–2.47)	25.7 (17.1–34.3)	1.67 (0.95–2.92)	30.5 (21.6–39.4)	1.29 (0.87–1.92)
Ever told by a health professional that asthma is probably work-related						
No (1131)	18.5 (16.1–21.0) ^f	1.00 (ref)	16.5 (14.0–19.1) ^f	1.00 (ref)	26.5 (23.5–29.5) ^f	1.00 (ref)
Yes (93)	34.1 (22.1–46.1)	2.76 (1.55–4.92)	31.8 (21.2–42.5)	3.08 (1.75–5.43)	51.2 (38.4–64.0)	3.56 (1.94–6.54)
Total	19.6 (16.9–22.2)		17.5 (14.8–20.3)		28.1 (25.0–31.3)	

CI, Confidence interval; ref, reference group.

^aThe numbers may not add to total because of missing values (0 for age, 0 for sex, 1 for race, 0 for Hispanic ethnicity, 2 for education, 44 for income, 5 for health insurance, 5 for smoking status, 0 for asthma attack, 0 for emergency room visit and 3 for ever told by a health professional that asthma is probably work-related).

^bResults presented as weighted estimate.

^cAdjusted for sex, education, income, health insurance, smoking status and ever told by a health professional that asthma is probably work-related.

^dAdjusted for age, sex, education, income, health insurance, smoking status, emergency room visit/urgent care and ever told by a health professional that asthma is probably work-related.

^eAdjusted for sex, education, income, health insurance, smoking status and ever told by a health professional that asthma is probably work-related.

^fIndicates significant association between the particular variable and workplace exposure as determined by the χ^2 statistics (p value <0.05).

^gIncludes American Indian/Alaskan Native, Asian, Black/African American and multiple races.

^hIn the past 12 months.